



Salisbury  
UNIVERSITY

Honor College at Salisbury University

Honors Thesis



An Honors Thesis Titled

Perceptual Learning with Corrective Feedback: Whose Handwriting is This?

Submitted in partial fulfillment of the requirements for the Honors Designation to the

Honors College

of

Salisbury University

in the Major Department of

Psychology

by

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Date and Place of Oral Presentation: 01 March 2019, NYC

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Running head: WHOSE HANDWRITING IS THIS?

Perceptual Learning with Corrective Feedback: Whose Handwriting is This?

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Honors Thesis Project: Psychology

14 December 2018

## WHOSE HANDWRITING IS THIS?

**Abstract**

Can humans learn visual categories using corrective feedback, as computers do?

Participants learned the handwriting style of three writers. Group one studied labeled handwriting samples; group two was presented unlabeled samples (no author name), made a response, and received corrective feedback regarding the author. Performance on this test was similar for each group, suggesting no advantage for either study method. It is theorized that a longer study phase may be needed for corrective feedback learning to occur.

## WHOSE HANDWRITING IS THIS?

## Perceptual Learning with Corrective Feedback: Who's Handwriting is This?

Some cognitive computing technologies can amass a huge amount of health data and recognize future health problems. Researchers provide these technologies with no rules; but rather present them with a great deal of information. For example, machines exposed to many trials of x-rays and descriptions of the presence/absence of tumors began to identify tumors in real x-rays faster and more accurately than the trained medical professionals. Understanding and investigating this information-processing method for learning contributes to the theoretical frameworks of human and machine learning. Turning to artificial intelligence (AI), understanding how a machine learns could be applied to human learning, such as providing improvements in study habits.

Conceptual thinking necessitates the use of mental categories. We organize similar, particular concepts into groups, and we then use the knowledge of those groups to interpret and understand future objects (Goldstein 2015). Children learn to categorize both whales and sharks as animals, and they also learn to distinguish between them and recognize differences. The category, or idea of a whale may differ from the particular whale you see. Each mental category contains similar characteristics, and we create our categories using similarity as a rule. We distinguish between objects through recognizing similarities and differences, but universal concepts exist intangibly. For instance, although all tables can be recognized to share same family of furniture, we notice differences between individual tables. Particular tables can range in size and shape, and our idea of a table functions as a mental prototype (Goldstein 2015). Mental prototypes make it easier to categorize



## WHOSE HANDWRITING IS THIS?

information, as we group similar objects in knowledge. Just as species contain genera, mental prototypes contain individual pieces of information. We infer the qualities of objects through our prior knowledge and experience, and we use our mental categories as a quick guide for recognition. The handwriting authors in this study function as prototypes, for the name of the author works as a category label which contains similar handwriting samples.

The present study investigated perceptual learning by humans for cursive writing samples. Cursive writing was chosen as it is highly idiosyncratic yet familiar, and participants were not expected to have much experience with this class of learning. Cursive handwriting samples were flipped upside-down to reduce semantic encoding of the words. If samples were presented right-side-up, participants would be able to read the words and therein think about the meaning of the words. Thus, turning the handwriting samples over preserves the style and form of the authors' handwriting, as well as reducing extraneous variables in the encoding process.

A control group learned by first seeing the name of the author and then seeing a handwriting sample. The experimental, or corrective feedback, group saw the handwriting sample before being informed of the author's name. The corrective feedback method was expected to mimic the process by which AI is implemented in perceptual learning situations, such as identifying tumors or learning categories of objects. It was hypothesized that humans would be able to learn via this method, and to do so faster via labeled feedback. Varying the order of stimuli presentation utilizes the feedback effect within the experimental group, given that these participants are shown the correct author after responding. The order of author name presentation is

## WHOSE HANDWRITING IS THIS?

the independent variable. It is the construct being manipulated in order to vary participant learning methods.

Kang, Pashler, Cepeda, Rohrer, Carpenter, & Mozer introduce the question, does generating an incorrect guess impair future learning of the correct information? (Kang 2011). While it is clear that guessing on multiple-choice tests gives learners an advantage, it remains unclear if guessing in the learning process interferes with future results. If a learner guesses, will they encode this wrong response as correct, or will they remember the fact that this answer *was* incorrect in future trials? Results from this study offer support for learning alongside incorrect guesses, as forced guessing did not impair participant recall results over progressing dates. Participants who were more receptive to this learning style and who were willing to offer a guess also performed better.

In the Bronx Project, Metcalfe and Kornell (2007) implemented a cognitive learning method in a grade 6 class. Sixth graders in the South Bronx learned vocabulary words either through a self-study method, or through a computer-assisted, self-generation method. In the self-study method, the sixth graders were given common study materials like flashcards and colored pencils. The computer-assisted program asked the children to generate the answers and guess the definitions of the vocabulary. This cognitive learning method utilized participant answer generation to improve recall, and this experimental group performed more than 400% better than the self-study method (Metcalfe & Kornell 2007). In their second study, Metcalfe and Kornell implemented this study over a seven-week period with a more refined program, and the success of the cognitive learning group rose to over 600% better than

## WHOSE HANDWRITING IS THIS?

self-study groups. This study was replicated with students learning English as a second language and with college students at Columbia University. Furthermore, they noted that the presence of errors within the self-generation method did not worsen performance (Metcalf & Kornell 2007). This study offers support for cognitive learning methods, especially those involving an active, generative learning process.

Others believe that errorless learning produces greater results for learners, given that they do not make mistakes in the learning process. Huelser and Metcalfe (2012) considered the theory which views errors as information which compete with correct knowledge, given that self-generation does improve recall in general (Huelser & Metcalfe 2012). Furthermore, Yan, Yu, Garcia, & Bjork noted “one justifiable concern about testing or generation is that what is retrieved, whether correct or incorrect, will be learned” (Yan et al. 2014). Investigating cognitive strategies for encoding information effectively is of utmost importance within the field of learning, and the theory of feedback learning depends on the generation effect.

Huelser and Metcalfe (2012) evaluated the feedback effect in eight conditions. Participants were tasked with recalling word-pairs, and groups were first divided between groups viewing related and unrelated word-pairs. Each group underwent a learning phase with three sections: an error-generation condition, a read-short condition (seeing the word-pair together for 5 seconds), and a read-long condition (seeing the word-pair together for 8 seconds). Participants were told to respond as fast as possible in the error-generation condition. Learning for these word-pairs was overall better in the related word-pair group, given that these words were easier to associate with each other. Across both related and unrelated word-pairs, future recall was best for those

## WHOSE HANDWRITING IS THIS?

word-pairs previously viewed in the error-generation condition (Huelser & Metcalfe 2012). Thus, the generation effect works best when stimuli are easy to associate together. While this learning method did not substantially improve recall within the unrelated word-pair group, recall for unrelated-word pairs was poor after each learning method.

Kornell, Hays, and Bjork (2009) offer further support for benefits of the generation effect in learning. Like the Bronx Project, their study involved a manipulated learning phase followed by a testing phase. Twenty-five UCLA students were asked to match fictional and nonfictional questions to their answers. Participants' study phase comprised both of trials with the question and answer presented together, and of longer trials with just a question presented. In the latter trials, participants were asked to generate the answer, whether the historical question was fiction or nonfiction. Participants did not suspect that some questions were fiction, and they answered many of these questions incorrectly in the learning phase. However, greater participant accuracy for fictional answers in the testing phase revealed that generating incorrect semantic answers did not affect testing performance for the same meaningful responses. If there was a negative effect of recall errors, they were outweighed by the benefits of encoding immediate feedback. This, in turn, improved encoding of the correct answer. Yan et al. (2014) also agree that learners can know what answer they first encoded incorrectly at the time of testing, and that the feedback after an incorrect answer may function as a cue for future recall (Yan et al. 2014).

Heit, Bott, and Briggs (2009) investigated category learning, especially for stimuli with incongruent features. Forty-six students from the University of Warwick



## WHOSE HANDWRITING IS THIS?

were asked to match descriptions of cereal to either a child's or adult's cereal brand. In this study, the child and adult cereal function as a category which contain the cereal descriptions. Participants were shown descriptions of the features of each cereal (ex. This cereal has a lot of sugar, this cereal is packaged in an opaque bag) and asked to match the features to either the children's or adult's cereal. Initially, participants had difficulty distinguishing between features of both categories. Over more observations, this research shows the positive effect of prior knowledge for critical stimulus features (Heit et al. 2004). Participants were exposed to filler features, or basic descriptions of cereal. Participants were also exposed to critical features of cereals which could be shared by either category. Recall for critical details improved significantly over progressing trials, which reveals support for the testing effect in general. Furthermore, participants were exposed to incongruent features of cereal types (ex. This cereal helps with insomnia), whose meanings were less directly related to cereal. Participant recall for critical features also improved with later trials (Heit et al. 2004). Thus, participants can also learn to distinguish between incongruent and abstract category members with practice.

The Greeble study by Gauthier and Tarr (1997) address the neuropsychological aspect of learning and recognition for complex stimuli. They investigated participant recall for computer-generated green beings (Greebles). The fusiform face area (FFA) contains neurons that respond best to faces (Goldstein 72), and these researchers evaluated FFA activity when encoding Greebles. They measured FFA activation over four days: before and after the participants had experience recognizing Greebles. Their results support experience-dependent plasticity, the mechanism through which

## WHOSE HANDWRITING IS THIS?

brain structure changes through experience (Goldstein 73). Furthermore, research indicated that FFA activation increased when recognizing Greebles over successive days: the fusiform face area is involved in the recognition of other complex stimuli, not only faces. It can be trained to recognize unfamiliar, complex stimuli like Greebles and even upside-down cursive handwriting. Although the present study did not measure brain activity directly, the FFA is most likely the brain structure involved in the learning of these complex handwriting stimuli.

### **Hypothesis**

It was hypothesized that an active learning phase with self-generation and computer feedback would improve participant recall for cursive word-author pairings more so than an inactive learning phase with simultaneous word-author presentation. Learners who are more engaged in their learning process should perform better than learners who are not asked to recall the information they are studying.

### **Methods**

#### **Participants**

Participants were recruited from the undergraduate psychology subject pool and a Cognitive Science class, and they received course credit for their involvement in the project. All participants were treated in accordance with APA ethical guidelines. Twenty-seven participants took this study. Their average age was 20.07 yrs., and 80% of participants were female. Three participant's responses were not included in analysis due to testing errors.

## WHOSE HANDWRITING IS THIS?

**Materials**

Microsoft PowerPoint was utilized to run the two versions of The Author Game. The experimental and control variations of The Author Game are in William McCarthy's possession, and are available electronically upon request. Scantron sheets and pencils (one per participant) were provided to each participant in order to record his or her responses. Participant forms were created by Dr. Becker, and they were distributed to each participant in order to gather Informed Consent and Demographic Information. Participants were given paper instructions during the experiment, and a debriefing form when they finished the experiment. These forms were included in the Appendix. Finally, the participant's amount of correct responses was entered into Microsoft Excel for data analysis.

**Stimuli**

Three authors contributed a word bank of 30 cursive words. Five individual handwriting samples from each author are shown below:

Author 1

Arachnid

Platypus

Coffee

Triangle

Mineral

Author 2

Arachnid

Platypus

Coffee

Triangle

Mineral

Author 3

arachnid

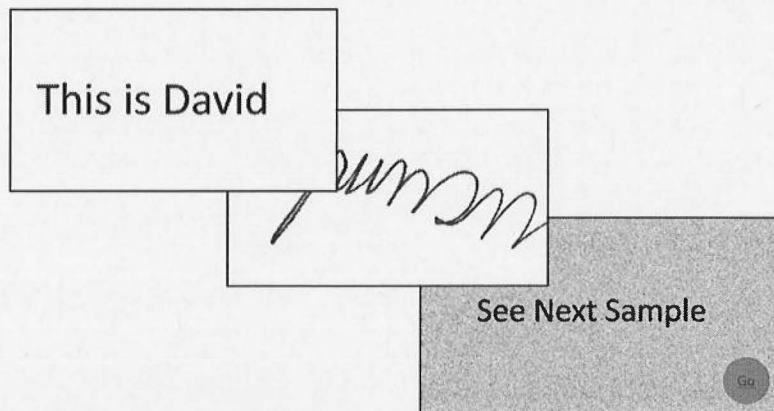
platypus

coffee

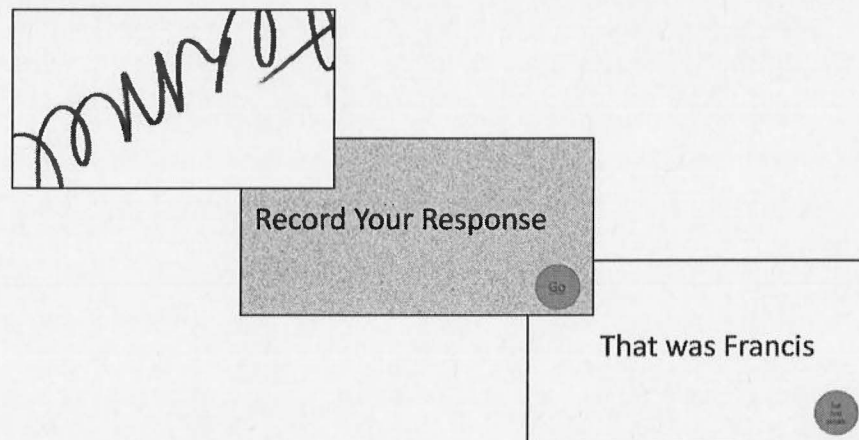
triangle

mineral

## WHOSE HANDWRITING IS THIS?

Control Learning Trial:*Fig. 1*

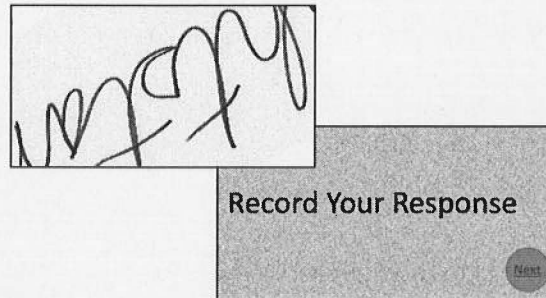
*Fig. 1*, an example of a control group learning trial, consists of a 2.25 second description (e.g. this is David), followed by a flipped cursive sample lasting .80 seconds. Lastly, a 1.0 second screen immediately follows each cursive stimulus to negate the retinal imprint of the sample. The retinal imprint occurs when the eye focuses on dark letters atop a light background. A similar example of a retinal imprint occurs when the eye views a camera flash and afterwards sees a darker imprint of the flash. Thus, a neutral colored screen reduces any lingering stimulus and also standardizes individual differences across participant's perceptions. After one second of viewing the screen, instructions (e.g. see next sample) and a 'Go' button appear.

Experimental Learning Trial:*Fig. 2*



## WHOSE HANDWRITING IS THIS?

*Fig. 2*, an experimental group learning trial, consists of the stimulus (.80 sec) and response screen (with a 1 second delay before instructions). The response screen immediately requests a participant's response. In this case, participants are given feedback (e.g. that was Francis) only after they have written their response.

Testing Phase Trial:*Fig. 3*

*Fig. 3*, a testing trial, is viewed by both groups. Each testing trial consists of the cursive stimulus, the retinal screen, and response instructions after a one second delay. No author feedback is given in these trials.

**Procedure**

Other than participants' signature on informed consent documents, all project data is anonymous; each participant's data is identified by number. The experiment was conducted in a Conway Hall computer lab. Participants arrived at the computer lab and were greeted by the student researcher—Mr. McCarthy. Students were individually seated at their own computer screen. Each participant was randomly assigned to one of two groups: *Labeled Learning* (LL), or *Feedback Learning* (FL). Participants in both groups underwent a learning phase and a testing phase:

Learning phase

LL participants were told to study a series of handwriting samples in order to learn to recognize the style of three different authors. Participants then viewed a series

## WHOSE HANDWRITING IS THIS?

of pairs of slides: the first in each pair indicated an author name, and the following slide contained a sample of handwriting from this author. Every author description was presented for 2.25 seconds, and every handwriting sample slide was presented for .80 seconds. Sixteen sample-pairs from each of the three authors were presented in mixed random order for a total of 48 samples.

FL participants also were instructed that their task was to recognize the handwriting style of three authors. They were informed of the author names in the beginning. The specific instructions were to identify the author of each sample after it was shown. The sequence of events on each trial was: handwriting sample—participant response—feedback (correct name of author). FL participants viewed identical sample slides as SL participants.

### Testing phase

Participants were presented with handwriting samples and they were asked to match these samples with the correct author. After stimulus presentation, participants were instructed to respond and pick one of three authors. Each handwriting slide was presented for .80 seconds followed by a blank slide that was viewed until a response was made and the participant chose to advance. Ten samples from each of the three authors were presented in mixed random order for a total of 30 test slides. There was no feedback during this phase.

## **Results**

An independent samples t-test was used to analyze differences in the test phase between the learning groups ( $n=24$ ). There was no significant difference between

## WHOSE HANDWRITING IS THIS?

performance on the 30 test trials from feedback learning participants ( $m = 11.61$ ,  $SD = 3.45$ ) and labeled learning participants ( $m=13.72$ ,  $SD = 2.38$ ),  $t(22) = 1.71$ ,  $p = 0.10$ .

Considering the most missed questions in the experimental learning phase and the most missed questions in the shared test phase, two notable findings emerge: 1) Over 76% of experimental learning phase participants responded incorrectly to five Author 3 trials, and 2) in the test phase these misidentifications of Author 3 were no more present than misidentifications of other authors. Given that experimental learning phase participants missed identifying Author 3 more than the other two authors, they may compare the first two authors more to each other than the third author. In the test phase, participants did not recognize Author 3 less than the first two authors, meaning that learners may consider the third author more heavily after the learning phase.

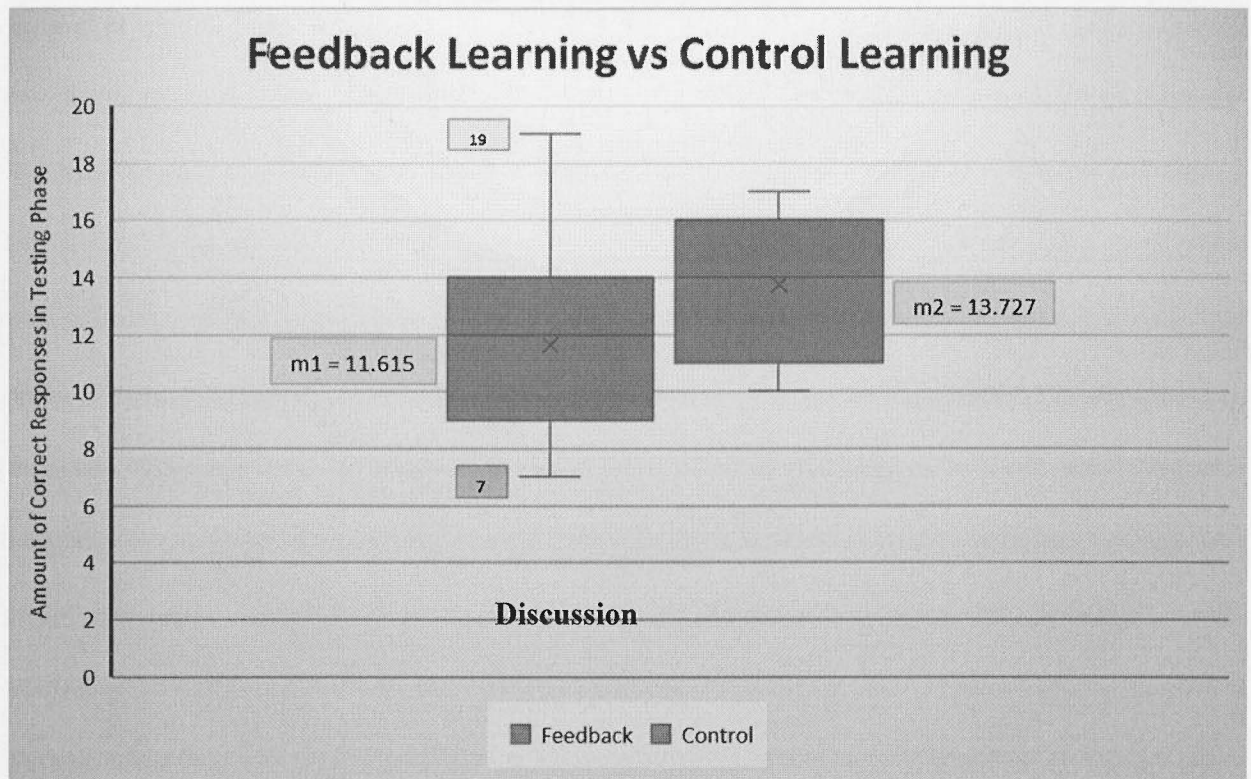
### Analysis

Seventeen participants performed better than chance (i.e. greater than 10 correct responses in the testing phase). The box-and-whisker plot below (*Fig. 4*) presents group Fl and Cl group performance in the testing phase. The control group performed better, on average, than the experimental learning group. However, neither group performed significantly better than guessing. Participants are guessing if their total amount of correct answers equals that of chance. Given that the participants were asked to choose between three authors, they have a 1:3 chance of guessing correctly. FL and CL groups did not perform significantly better than chance. Lastly, one learner in the experimental group correctly responded for 19 out of 30 test questions. This participant performed almost double that of chance, as they correctly identified 63.3%

## WHOSE HANDWRITING IS THIS?

of test phase samples. This learner's performance could be due to individual skill, or this learner could be very receptive to the feedback learning method.

Fig. 4



Current applications of artificial intelligence programming indicate that computers are able to engage in perceptual learning via corrective feedback. We wondered whether humans could do the same. Our results showed, however, no difference in learning for the groups that learned via labeled samples and the group that used corrective feedback.

After participants had completed the study, they were asked what they thought about the study. Some learners said that this task was difficult, and others responded that they began to recognize patterns within the letters, specifically in the way that the authors formed their t's and i's. Further research will consider the role of preexisting



## WHOSE HANDWRITING IS THIS?

participant constructs in their learning styles, including gender, age, major, and class standing.

A possible explanation is that corrective feedback learning simply does not confer any benefit on the perceptual learner beyond that of other learning methods. More likely is that we experienced floor effects, for both groups performed only slightly better than chance (note that each group did have some vastly superior performers, so learning was possible, just not universal). As such, what we may have learned is that the number of study examples used was not sufficient for true learning of these difficult categories. In response, we are now exploring this by conducting a version of this study with a substantial increase in the examples and time allocated to the learning phase.

## WHOSE HANDWRITING IS THIS?

### Appendix

#### Contents

I.	<i>Participant Forms</i>	
a.	<i>Informed Consent</i>	<i>p.</i>
b.	<i>Demographic Information Form</i>	<i>pp.</i>
c.	<i>Participant Instructions</i>	<i>pp.</i>
d.	<i>Debriefing Statement</i>	<i>p.</i>

## WHOSE HANDWRITING IS THIS?

## INFORMED CONSENT: RECALL LEARNING: WHOSE HANDWRITING IS THIS?

Dr. Larence Becker of the Psychology Department and William McCarthy of the Honors College are conducting a study on the learning of visual categories.

**Procedure.** During the study you will match cursive handwriting samples to their authors. The study is conducted on a computer screen on which you will view samples of cursive handwriting. In the first, or study phase, you will learn the handwriting styles of three authors. In the recognition phase your task is to match a series of samples to their author.

**Risks.** There are no known risks involved other than what would be encountered reading an article on a computer screen. You will also be asked to complete some demographic questions (e.g., age and gender). Please be aware that at no time will you be asked to put your name on any of the materials and we will make no attempt to match your name to any of your responses. To assure your anonymity we will not be collecting any information that can identify you.

It should take no more than 45 minutes to complete the study. General Psychology students will receive one unit of extra credit for their participation. The amount of extra credit given to those participating in upper-division classes will be determined by the individual professors.

While your cooperation and participation are greatly appreciated, participation in this research study is strictly voluntary; your participation or lack thereof will not affect your academic standing at this institution in any way. Choosing to withdraw from this study is your choice and will in no way affect your standing at this institution.

**Benefits.** Your participation is valuable and will help us further understand how people learn to recognize visual categories.

Signing this form signifies your consent to participate in this research.

If you have any questions about this study or would be interested in the results, please contact **Dr. Larence Becker** [lxbecker@salisbury.edu](mailto:lxbecker@salisbury.edu), 410-677-0033 or **The Office of Graduate Studies and Research at Salisbury University** at 410-548-3549 or toll free 1-888-543-0148.

Thank you for your cooperation,

Dr. Larence Becker  
Assistant Professor of Psychology  
Salisbury University

I have read the above information and agree to participate in this research.

Signature \_\_\_\_\_ Date \_\_\_\_\_

WHOSE HANDWRITING IS THIS?

# \_\_\_\_\_

**Demographic information:**

Please answer the following questions as accurately as possible. If you have any questions feel free to ask the experimenters.

\*If you do not have a declared major please indicate the one in which you are most interested.

Major: \_\_\_\_\_

Minor: \_\_\_\_\_

Class: (circle one) Fr. So. Jr. Sr.

Age: \_\_\_\_\_

Gender: \_\_\_\_\_



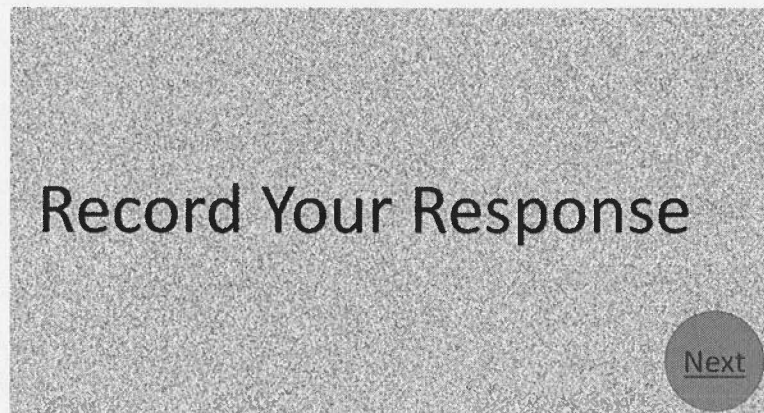
## WHOSE HANDWRITING IS THIS?

Dear Participant,

In your testing phase, you will be asked to respond after each trial

*Every fifth slide is numbered* in case you lose track of your scantron responses

After each trial, a screen will appear and say 'Record Your Response'



**Please make sure to mark your response before pressing 'Next'**

After you press 'Next', you will start the next trial

### **Scantron Key:**

A = David  
B = Sophia  
C = Francis

Thank you for your participation.

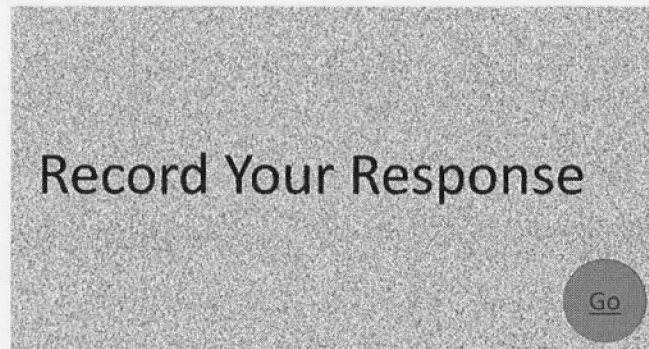
## WHOSE HANDWRITING IS THIS?

Dear Participant,

In your learning phase, you will be asked to respond after each trial

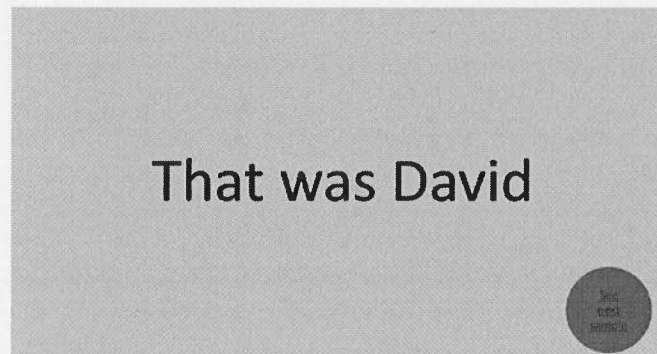
*Every fifth slide is numbered* in case you lose track of your scantron responses

After each trial, a screen will appear and say 'Record Your Response'



**Please make sure to mark your response before pressing 'Go'**

After you press 'Go', you will be shown the correct response (ex. That was David)



**Please only press 'See next sample' after you have seen this feedback**

### Scantron Key:

A = David  
B = Sophia  
C = Francis

Thank you for your participation.

## WHOSE HANDWRITING IS THIS?

## Debriefing Statement

The purpose of this study was to investigate and compare the effectiveness of different modes of learning visual categories. There were no known risks in this study beyond those of viewing an article on a computer screen. Benefits of this study include gaining a greater understanding of the effectiveness of testing and feedback in visual learning.

We investigated the accuracy of your responses while considering your learning condition: Both groups saw samples from the three authors during the study phase of the experiment. For one group the author was identified before viewing each sample; the second group saw each sample and then tried to recognize the author. Following the response they were informed of the proper name. In the recognition phase, each group saw a series of slides and tried to recognize the authors, one slide at time without feedback.

We hypothesized that the group that learned the authors through testing/feedback would match handwriting to authors more accurately than the no-feedback group. This is due to how testing reinforces encoding strength leading to better recall learning. If you would like to learn more about this, we recommend the following article:

Yan, V. X., Yu, Y., Garcia, M. A., & Bjork, R. A. (2014). Why does guessing incorrectly enhance, rather than impair, retention? *Memory & Cognition*, 42(8), 1373-1383.  
doi:10.3758/s13421-014-0454-6

If you have any questions about this study or would be interested in the results, please contact Dr. Larence Becker [lxbecker@salisbury.edu](mailto:lxbecker@salisbury.edu), Department of Psychology, Salisbury University.

If you have any adverse effects or concerns about the research, please contact the primary investigator or the University Research Services Department at Salisbury University at 410-548-5395 or toll free 1-888-543-0148.

*We would appreciate it if you would not discuss this study with others, as this experiment is ongoing and knowledge of the hypotheses could change people's behavior.*

*In addition, please do not reveal the identity of other participants or the nature of your interactions.*

Thank you for your participation,

Dr. Larence Becker  
Assistant Professor of Psychology  
Salisbury University

## WHOSE HANDWRITING IS THIS?

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